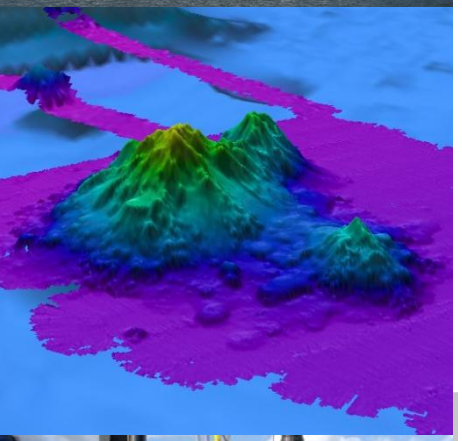

Deep Ocean Bottom Characterization

Today's Tools and Methods, and Challenges to Apply Advanced Autonomous and Remotely-piloted Technologies and Sensors

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NOAA Office of Ocean Exploration and Research

EXPLORE

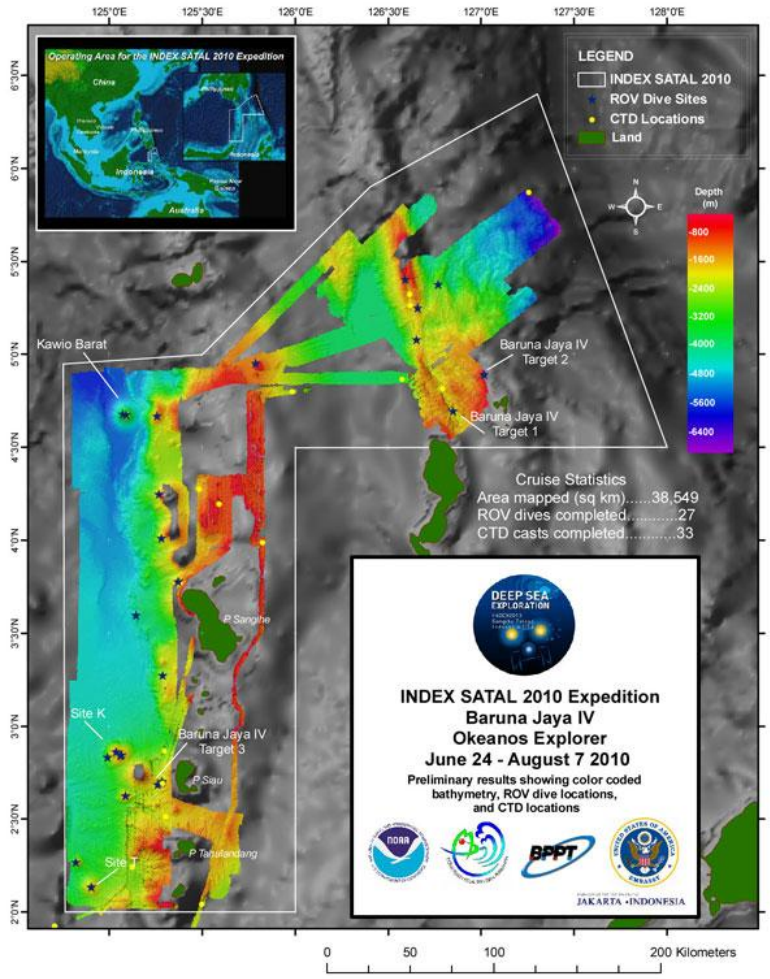
NOAA Deep Ocean Exploration Requirements

- 2000 President's Panel for Ocean Exploration mapping at new scales emphasizing regions not previously observed

- Public Law 111-11 authorized NOAA to conduct interdisciplinary voyages of ocean exploration

- NOAA Next Generation Strategic Plan Goal: *Healthy Oceans*: improved understanding of ecosystems to inform resource management decisions

Ocean Exploration
Bottom Characterization Challenges TODAY



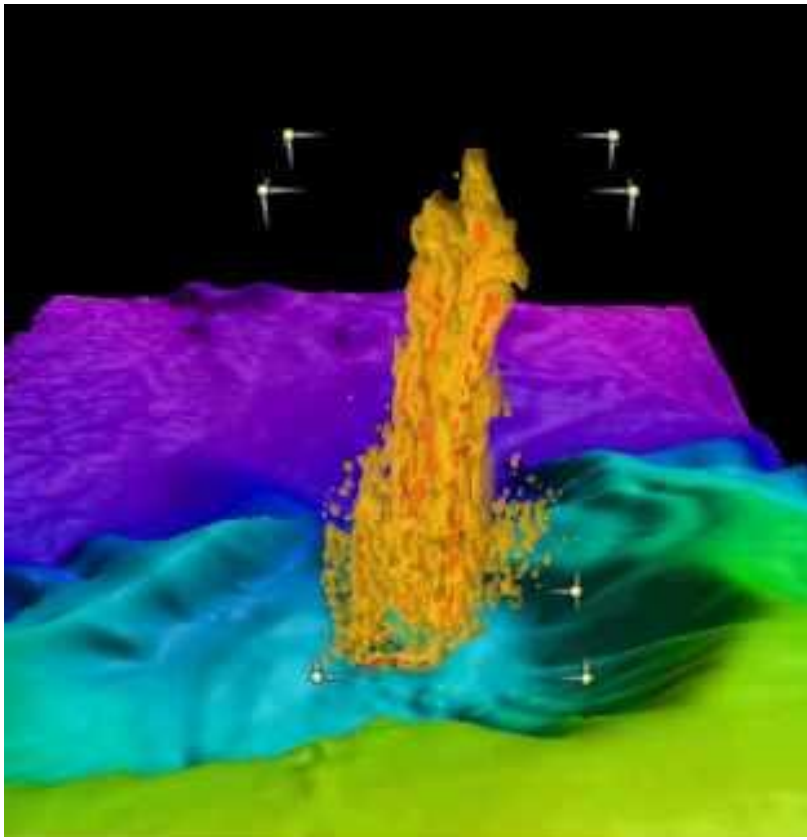
- Some physics of ocean exploration
  - Ship based acoustic method with resolution of tens of meters
  - AUV/ ROV can provide centimeter resolution but can only cover a small area on the seafloor
- Coarse resolution seafloor maps for AUV/ROV operations
- Need pervades to reduce cost and increase pace of deep ocean exploration

Okeanos Explorer Program Overview

- "America's ship for Exploration" has conducted 30 expeditions since 2008
- Tools include
  - Telepresence
  - Multi-Beam Echo Sounder
  - Remotely Operated Vehicle
  - Sub-bottom Profiler
  - Autonomous Underwater Vehicle (Capable)

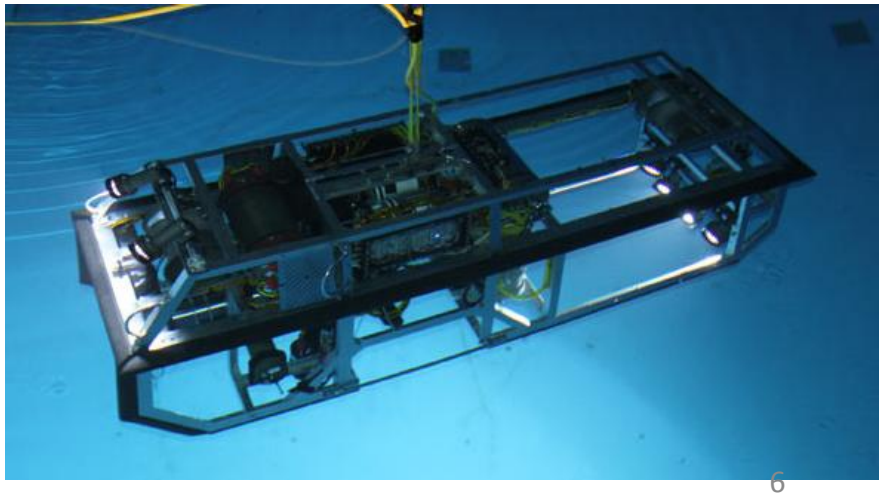
Tool: EM 302 Multi-beam

- Rated to 7000 m of water depth
- High resolution bathymetry
- Backscatter aids seafloor and water column characterization
- Operated in the Pacific, Caribbean, and Atlantic to map subduction zones, volcanoes, seamounts, Mid-Cayman Rise, gas seeps and submarine canyons
- Total area mapped since 2008 578,269 ^{2} Km



Tool: ROV – HD video

- Two-body ROV system rated to 6000m (2013) carries HD cameras and lights
- Sensor packages for manipulators under development
- Provides closer look to characterize features and habitats of interest



What Sonar Did Not See (But the ROV Did)

Image of a squid captured over loose rock

Image of hydrothermal vents

http://oceanexplorer.noaa.gov/okeanos/explorations/10index/#

Tool: Autonomous Underwater Vehicle (Capability)

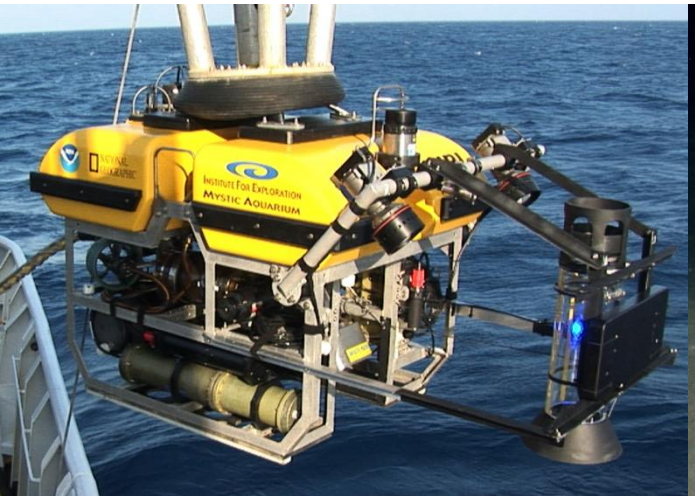
- NDSF/WHOI Sentry AUV, 6000m capable
- Multibeam, sidescan, subbottom, gradiometer, digital bottom photography
- Also: Nakamura redox potential probe, 3-D imaging system, and in-situ mass spectrometer

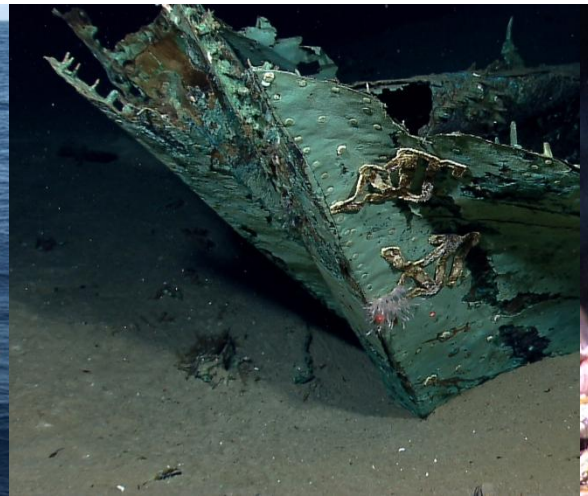
Tool: Telepresence

- Ability to send data, HD video, products and communicate in near real-time with scientists ashore
- 20 Mbps (megabits per second) upload and 5 Mbps download
- Distributed via I1 and I2
- Requires high band width satellite link with associated costs

Expedition: Gulf of Mexico 2012

- Purpose:
  - Investigate deepwater benthic habitat areas in the northern Gulf of Mexico including gas seeps
- Products:
  - High resolution bathymetry and imagery of post Deep Water Horizon environment, acoustic data of gas seep detection and gas flux

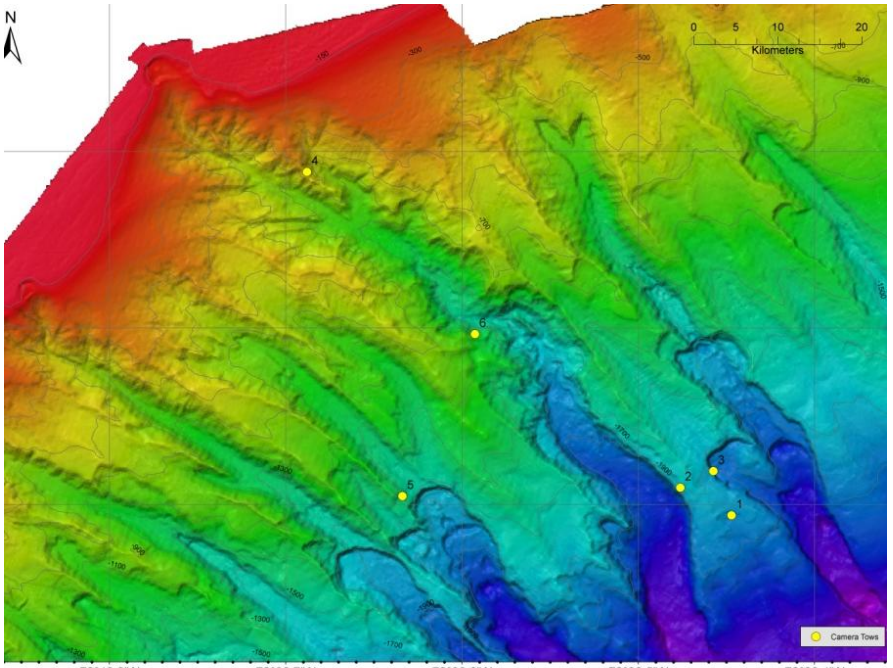




Atlantic Canyons Mapping Expeditions 2012

- Purpose:
  - To map poorly known canyons that provide refuge to corals, fish and other species with high interest to federal and state managers
  - Three NOAA ships

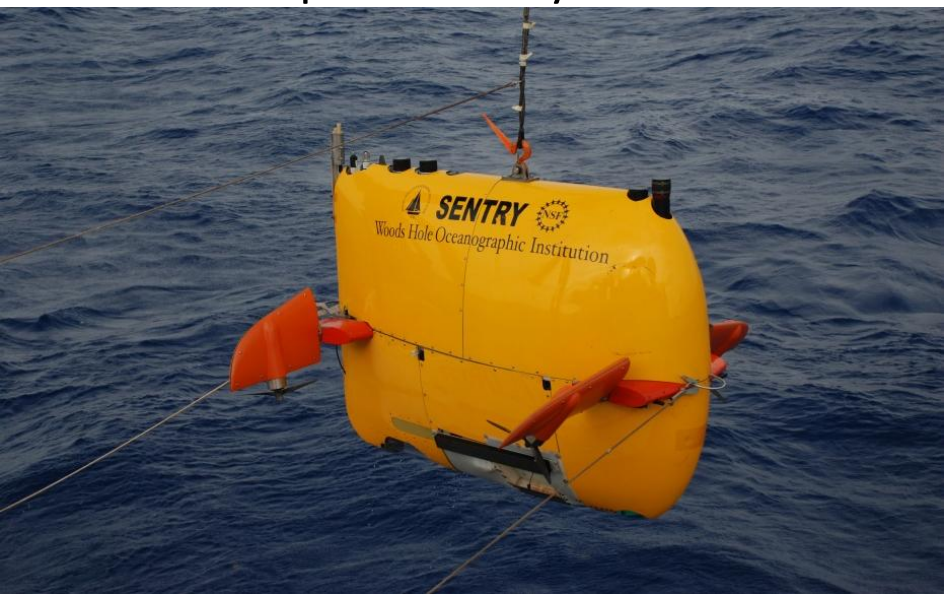
- Products:
  - > 10,000 linear kilometers mapped including all or part of 36 canyons
  - Located deep-sea coral and sponge communities with a towed camera system
  - Inform future ROV / Tow Camera dives



Toms Canyon Complex

Telepresence-enabled Exploration using AUV Sentry - 2012

- Purpose:
  - Proof of concept to operate AUV Sentry on NOAA Ship *Okeanos Explorer* using telepresence technology while exploring seep habitats on the Blake Ridge and Cape Fear diapir system
- Products:
  - Established new method to effectively prospect for cold seep environments on the deep seafloor
  - High resolution multibeam and sidescan sonar survey, chemical data, optical survey of features and habitats of interest



Blake Ridge Mission Team

Ship

Shore

WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

NATIONAL DEEP SUBMERGENCE FACILITY
WHOI
NSF • ONR • NOAA

OCEAN EXPLORATION & RESEARCH

Duke
NICHOLAS SCHOOL OF THE ENVIRONMENT
DUKE UNIVERSITY MARINE LAB

UNIVERSITY OF Rhode Island

NSF

USGS
science for a changing world

Looking Ahead to 2025 and Beyond:

Challenges to *Increase Pace, Scope and Efficiency* of Ocean Exploration

- Holistic View: System Architecture Requirements
  - Assess and broadly characterize a large ocean area
  - Identify and prioritize specific targets of interest
  - Conduct more in-depth exploration and characterization of these targets
- Platform View
  - Improvements for long duration operations, high area coverage rates, high data quality, real-time data transmission to shore with visualization

Challenges to Increase Pace, Scope and Efficiency

Technology View

Sensors

How might we improve the use of acoustical, optical and electrical (inductive) technologies to increase the pace, scope and efficiency of exploration - remotely and *in situ* - while lowering costs?

How might we eliminate the need to collect samples using *in situ* analysis of biological, chemical, physical targets by collecting digital data instead – e.g., Mars Curiosity robotic rover using remote sensing, analysis and telepresence?

Signal Processing of Habitat, Resource and Water Column Mapping Datasets

How might we mine backscatter data to better correlate bottom types with habitat types and other natural resources, and quantify the level of uncertainty associated so as to best identify and prioritize potential locations for further detailed exploration?

Visualization: How might we use visualization tools to enhance our comprehension and usage of bathymetric and backscatter data and information?

Challenges to Increase Pace, Scope and Efficiency

Grand Challenge View

- How might we perform the aforementioned expeditions using autonomous or semi-autonomous vehicles only?
- How might we map and characterize large geographical features like the entire Mid Atlantic Ridge using only autonomous vehicles?
- How might we access extreme environments like the Arctic Ocean or Mariana Trench for sustained periods to map, characterize the bottom and water column, and collect biological, chemical and physical oceanographic data?

Final Thought: Mars Rover Analogy to Deep Ocean Bottom Characterization?

http://www.nasa.gov/mission_pages/msl/news/msl20121003.html

What might an advanced ocean exploration “system” look like that includes a wide-area assessment tool coupled with Ocean Basin Rovers?

Links

- Email Address: Tim.Arcano@NOAA.gov
- Office of Ocean Exploration and Research
  - http://explore.noaa.gov/
- Public Law 111-11 authorizing NOAA's Ocean Exploration program
  - http://service.ncddc.noaa.gov/rdn/oer-public/media/documents/about-oer/plaw-111.pdf
- Presidents Panel Report on Ocean Exploration
  - http://service.ncddc.noaa.gov/rdn/oer-public/media/documents/about-oer/program-review/presidents-panel-on-ocean-exploration-report.pdf
- NOAA Next Generation Strategic Plan Goals
  - http://ppi.noaa.gov/ngsp/goals/